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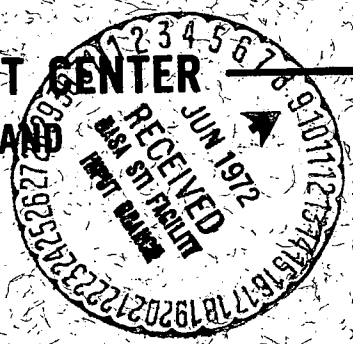
DATA ACQUISITION AND PROCESSING HISTORY FOR THE EXPLORER XXXIII (AIMP-D) SATELLITE

THOMAS J. KARRAS

APRIL 1972

GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND



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EXPLORER XXXIII (AIMP-D) SATELLITE

Thomas J. Karras
AIMP-D and -E Data Processing Engineer

Data Processing Branch
Information Processing Division
Mission and Data Operations Directorate

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ABSTRACT

The Data Acquisition and Data Processing History results for the Explorer XXXIII (AIMP-D) Satellite are presented. The Quality Control Monitoring System (QCMS), using the Information Processing Division's Accounting and Quality Control data bases, has made it possible to perform this in-depth analysis. Results show that the percentage of useable data files for experimenter analysis was 97.7%; only 0.4% of the data sequences supplied to the experimenter exhibited missing data. The 50 percentile probability delay values (referenced to station record date) indicate that the analog tapes arrived at the IPD within 11 days, the data were digitized within 4.2 weeks, and the experimenter tapes were delivered in 8.95 weeks or less.

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DATA ACQUISITION AND PROCESSING HISTORY FOR THE EXPLORER XXXIII (AIMP-D) SATELLITE

I. INTRODUCTION

A. Purpose

This report presents the Data Acquisition and Data Processing History results for the Explorer XXXIII (AIMP-D) Satellite. The AIMP-D telemetry data were acquired from Launch (July 1, 1966) to November 1, 1971. The Data Acquisition coverage, Data Processing results, and three major system delays are presented. The three system delays, referenced to the Data Acquisition Station (record date) are: (1) GSFC receipt date, (2) GSFC Digitization date, and (3) GSFC shipping date of experimenters' tapes.

B. General Discussion

The AIMP-D Satellite was launched July 1, 1966 at 1602 hours GMT in a highly-elliptical orbit about the earth after it was determined that a lunar orbit was not attainable. The perigee and apogee were approximately 100,000 kilometers and 500,000 kilometers respectively; the period was approximately 18.5 days.

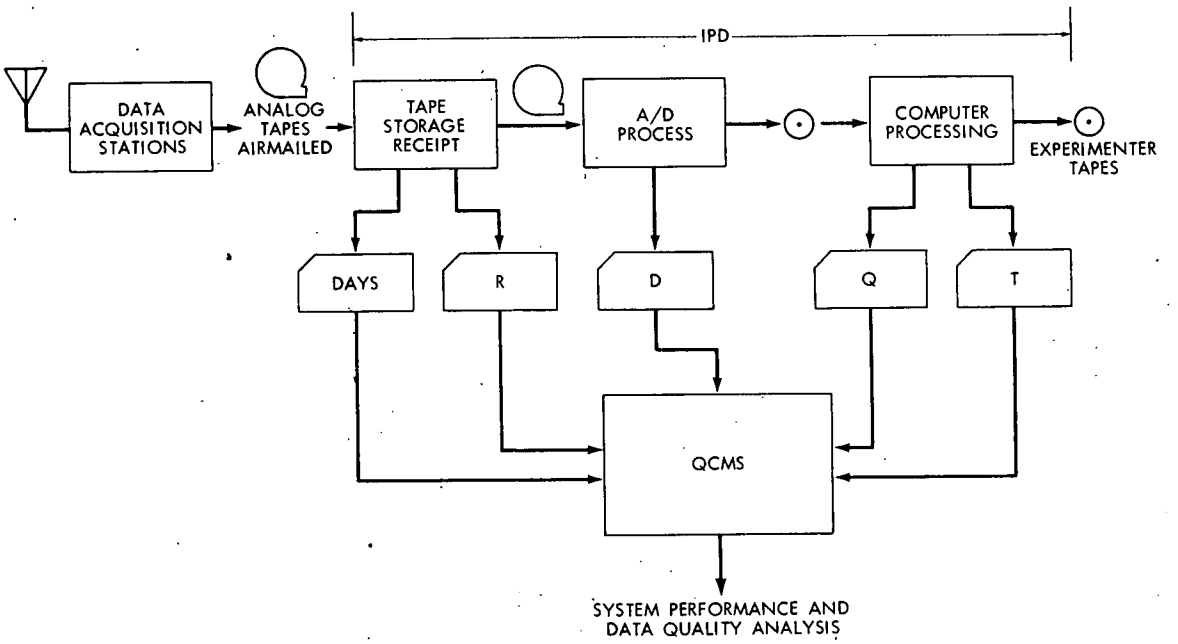
The telemetry type employed for encoding the scientific data was Pulsed Frequency Modulation (PFM). The telemetry data and other pertinent timing information were recorded at 1-7/8 ips on 7-track analog recorders at the NETWORK stations. An average pass was 2-1/2 hours; an analog tape contained from one to four passes (analog files).

The analog tapes were flown to GSFC for processing at the Information Processing Division (IPD). The time-of-receipt and other information were logged in the IPD accounting system. The analog tapes were digitized at a 16 times speed-up factor on the PFM F-8 A/D conversion line. After digitization, the data files were processed on the IBM 7010 Computer where editing and decommutation of experimenter tapes were performed. Those files which were processable resulted in the generation of data quality cards.

The final disposition (data quality and various process dates) of each file was placed on accounting and quality cards. These cards were analyzed using the Quality Control Monitoring System (QCMS)* to obtain the statistics and plots found in this report.

*Karras, T. J., "A Quality Control Monitoring System for Satellite Telemetry Data Information Systems," NASA, GSFC, X-563-69-212, May 1969.

Figure 1 contains an overview of the Data Acquisition, Data Processing, and Data Analysis functions pertinent for this report. Shown are the NETWORK stations and the IPD's A/D and computer processing, the accounting and quality cards, and the QCMS.



NOTE: 1. "Q" records the quality of the experimenter files.
2. The accounting cards record the following per file:
   a. DAYS → Data Acquisition Record Date
   b. R → IPD Tape Receipt Date
   c. D → IPD Digitization Date
   d. T → Experimenter Tape Shipped Date

Figure 1. AIMP-D Systems Analysis Flow

II. INFORMATION SYSTEM PERFORMANCE

A. Data Acquisition Interval and Coverage Analysis

The AIMP-D data acquisition support can be divided into two areas: (1) Normal support - July 1, 1966 through November 14, 1969, and (2) Special support - November 15, 1969 through November 1, 1971. The special support consisted of the following: (a) Processing of "warehouse stored data" (data acquired between November 15, 1969 and termination of data acquisition on January 13, 1970), (b) Partial operations of AIMP-D beyond its planned lifetime during periods when the spin axis-sun angle was between 70° and 110°), (c) Apollo(s) Support, and (d) Data processing of analog data acquired by the University of Iowa facilities after July 1, 1970.

Figure 2 is a plot of the complete Data Acquisition Interval (record dates on both x and y axis) for the AIMP-D Satellite. A total of 14,603 analog files (passes) were recorded. Figure 3 is a plot of the coverage obtained over 7-day averages; the analog start and stop times are used with redundancy (overlap) times removed and the total (percentage) minutes of coverage found in each 7-day interval was computed and plotted. Figure 4 is a plot of the "envelope" of Figure 3.

Figure 5 shows the file-to-file coverage over the first 3-months of AIMP-D. The average coverage scheduled for this period was approximately 96.75% while the overlap (redundancy) was 14.3%. Figure 6 depicts the gaps (inverse of Figure 5) over this same 3-month interval.

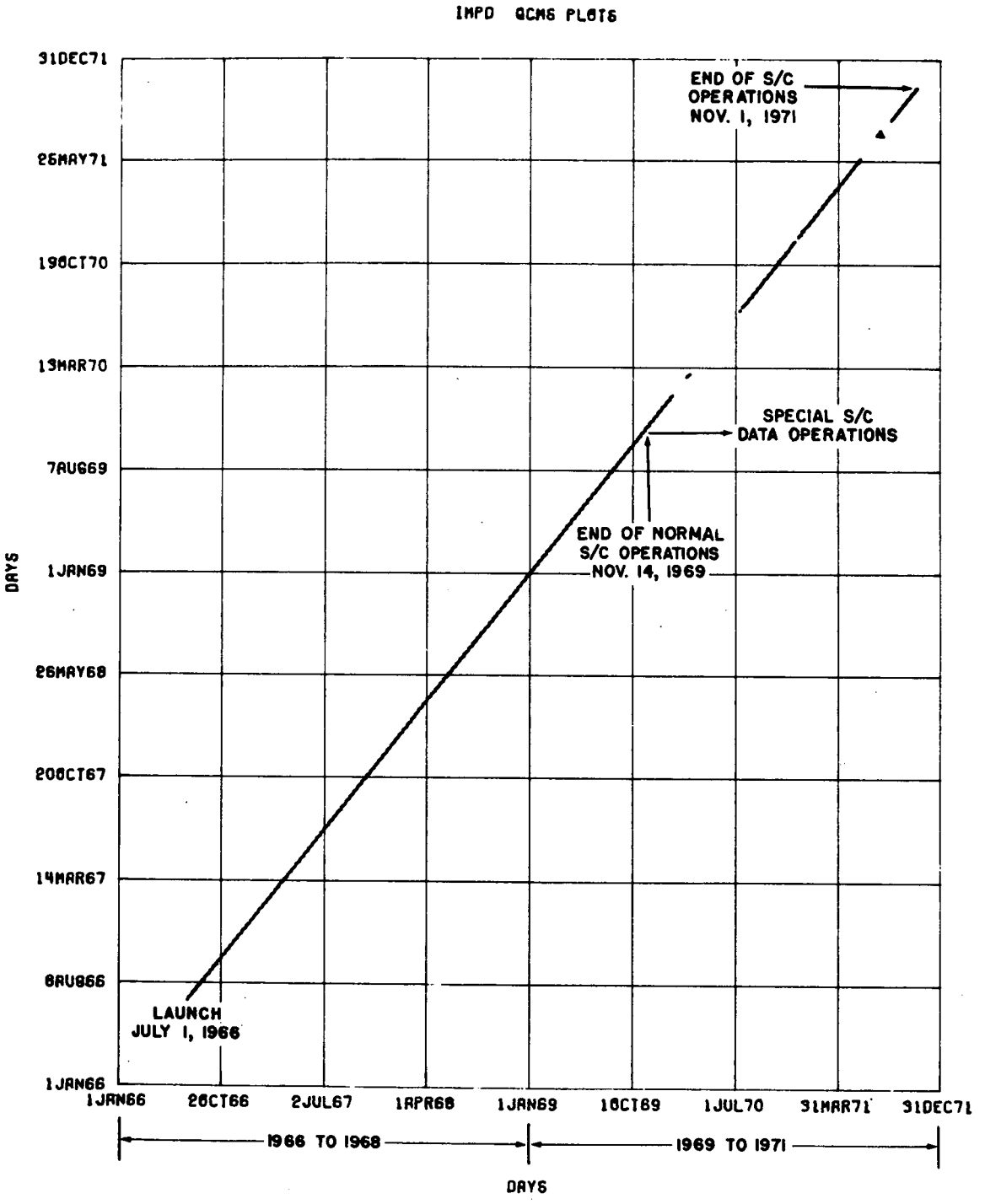


Figure 2. AIMP-D Data Acquisition Intervals (14,603 Files Recorded)

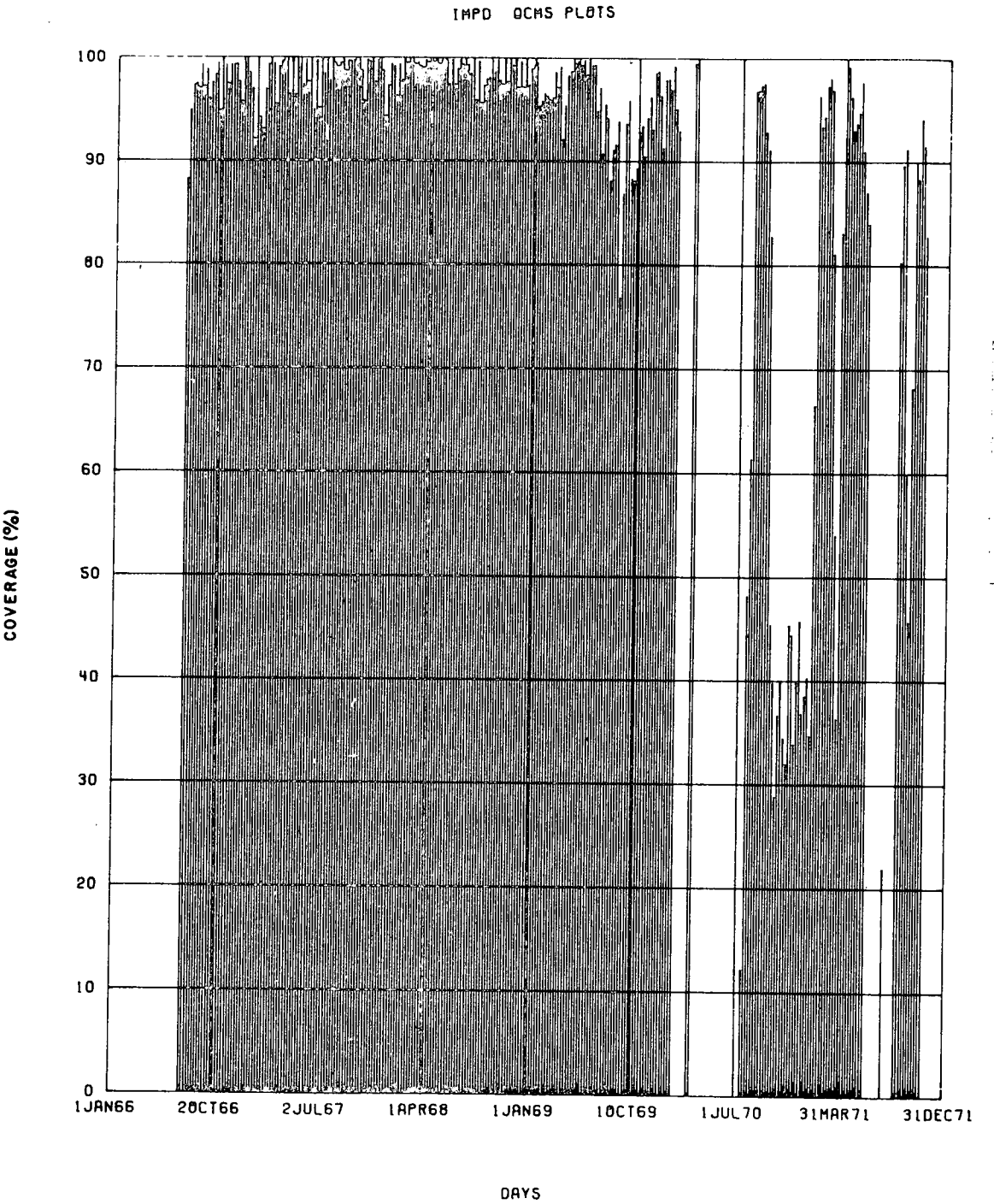


Figure 3. AIMP-D Data Acquisition Analog Tape Coverage (7-day Averages)

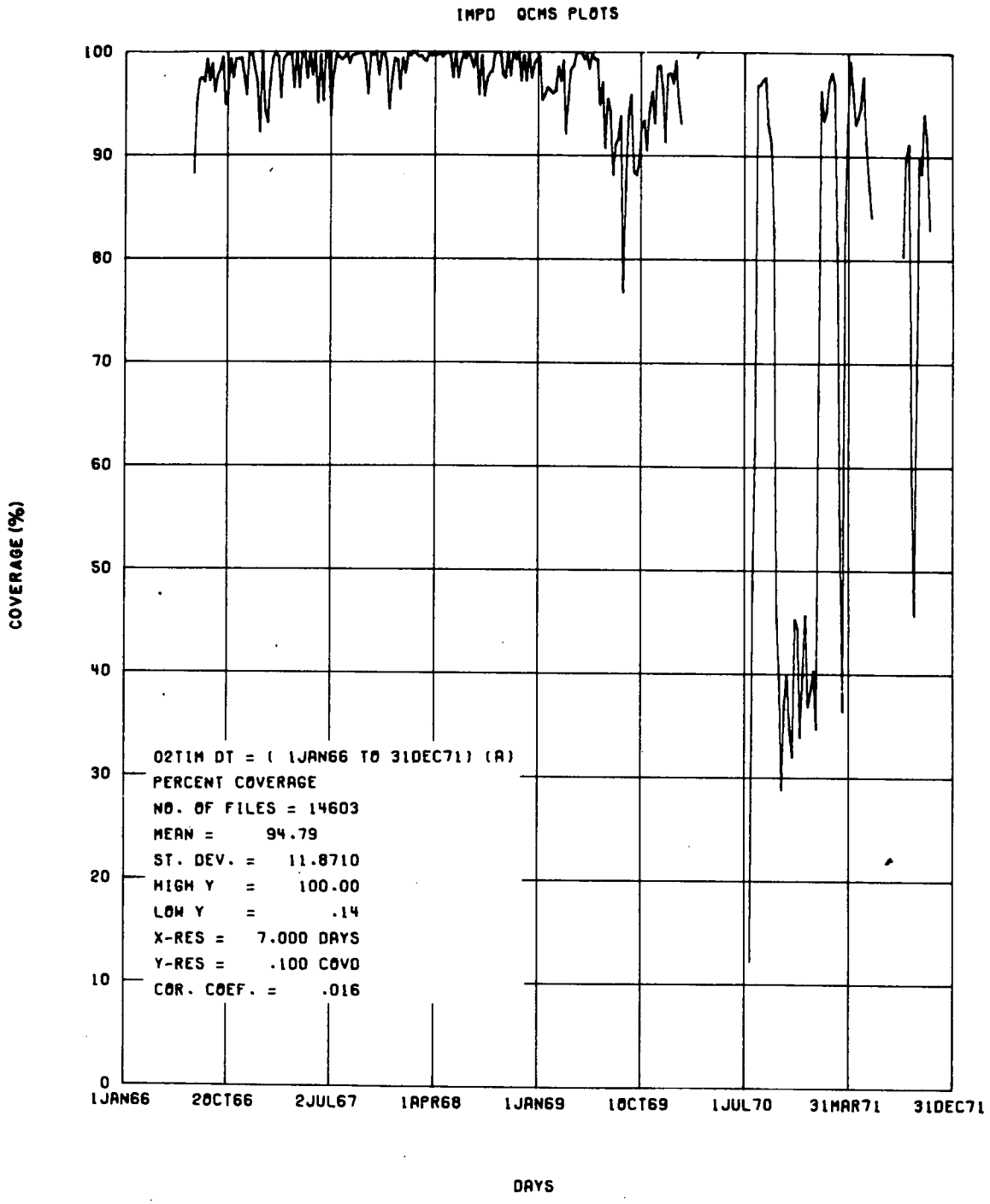


Figure 4. AIMP-D Data Acquisition Analog Tape Coverage, 7-day Averages (Plot is the Envelope of Figure 3)

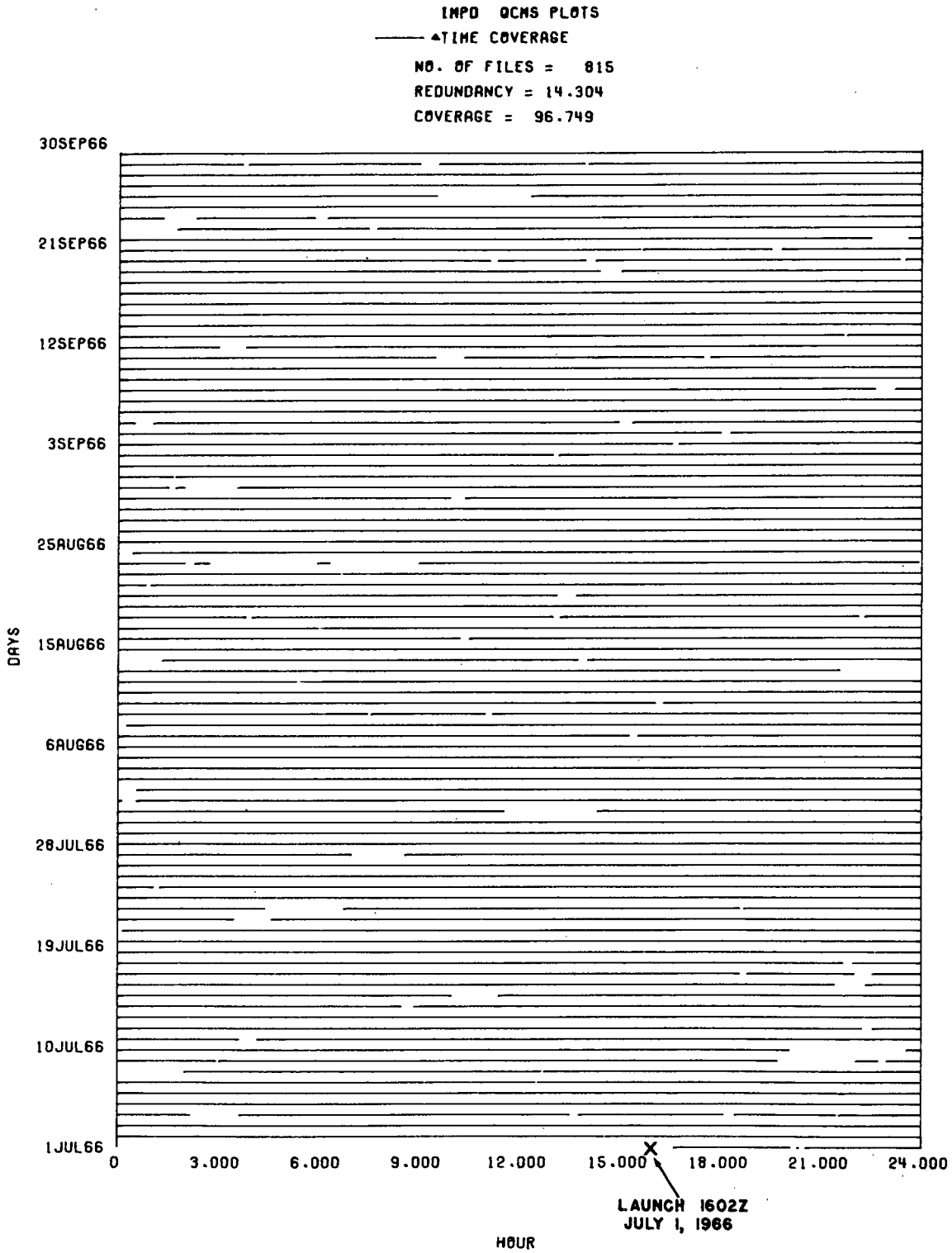


Figure 5. Example of AIMP-D File-to-File Coverage from July 1, 1966 through September 30, 1966

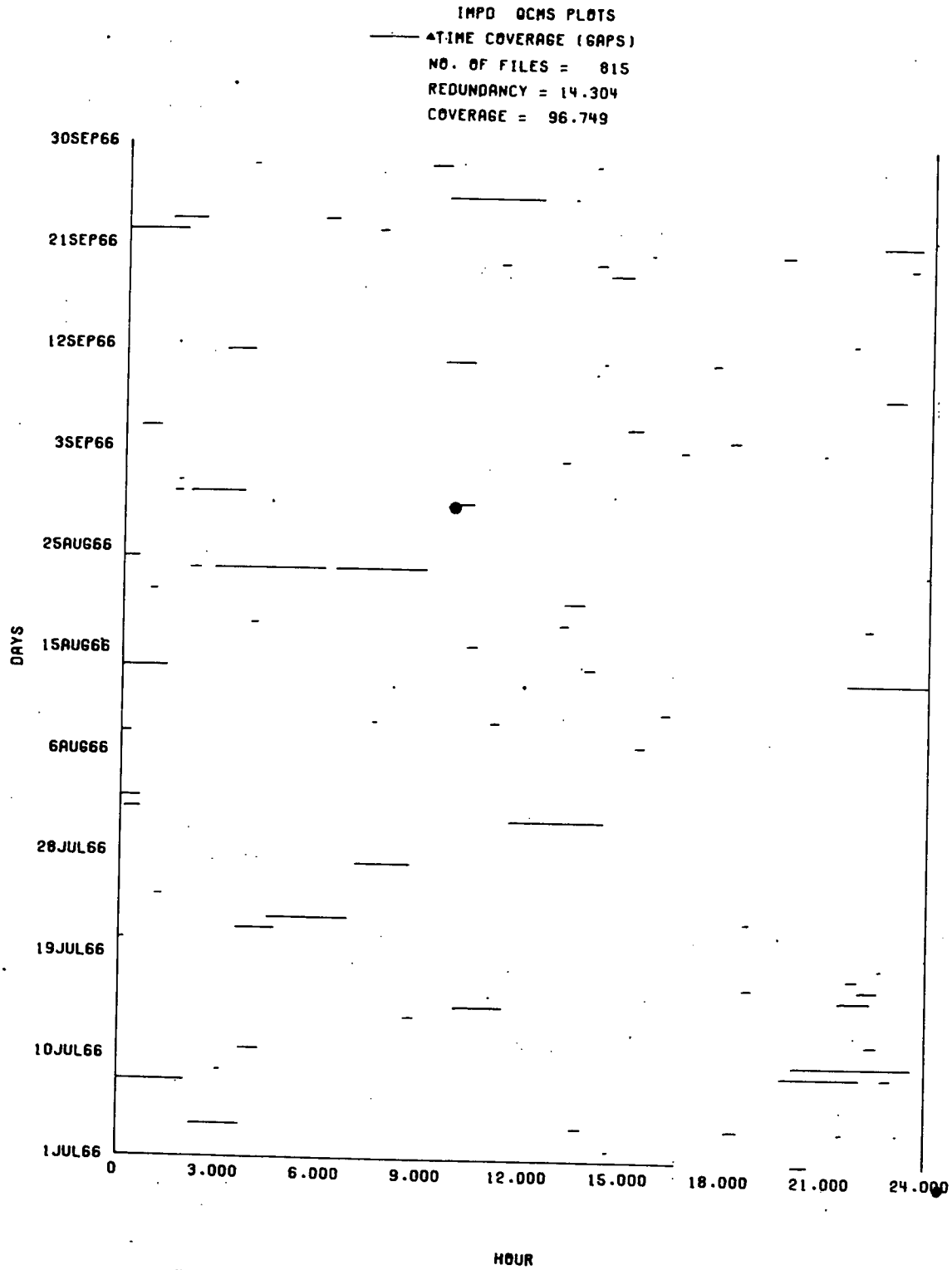


Figure 6. Example of AIMP-D File-to-File Gaps from July 1, 1966 through September 30, 1966

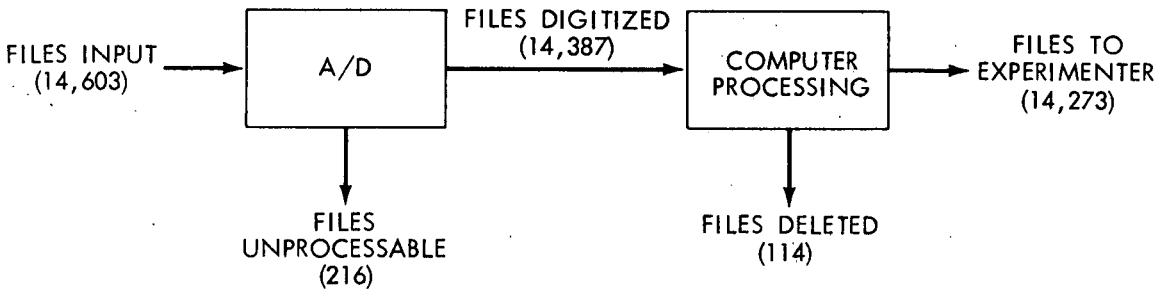
B. Data Processing Efficiency

The Data Processing System Efficiency is defined in this report as the ratio of the files shipped to the experimenters to the input files received from the NETWORK stations. Figure 7 depicts this efficiency flow within the IPD. For the 14,603 input files, 216 were determined unprocessable at the A/D line and 114 files were deleted (culled) in the computer processing. The Data Processing Efficiency (% useable files) was 97.7%.

Those files during digitization which were found to be unprocessable were assigned a file status code to identify the unprocessable (UPCD) reason. Figure 8 is a bar graph of the file status codes identifying the 216 unprocessable files. Observe that the UPCD = 30 (insufficient data to process) was the most predominant unprocessable code.

Those files (14,387) which were digitized but could not be processed on the IBM 7010 were deleted (culled). A total of 114 files fell into this category.

Figure 9 is a bar graph by NETWORK station input files (solid bar) and useable files (dashed bar). The percentage useable files recovered is tabulated in Table I.



$$\% \text{ FILES USEABLE} = \frac{14,273}{14,603} \times 100\% \approx 97.7\%$$

Figure 7. Data Processing System Efficiency Flow for AIMP-D

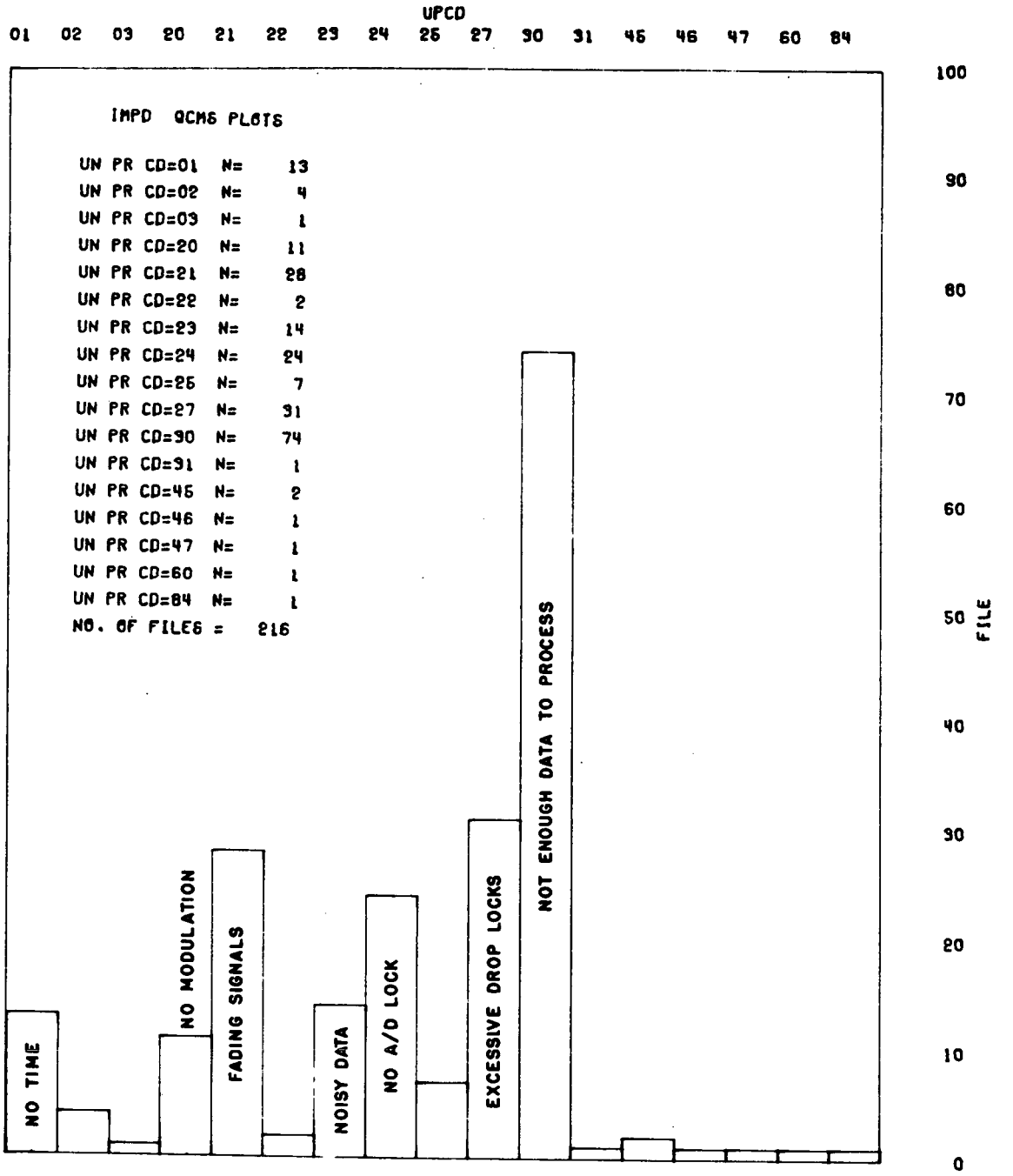


Figure 8. AIMP-D Unprocessable File Status Codes (UPCD)

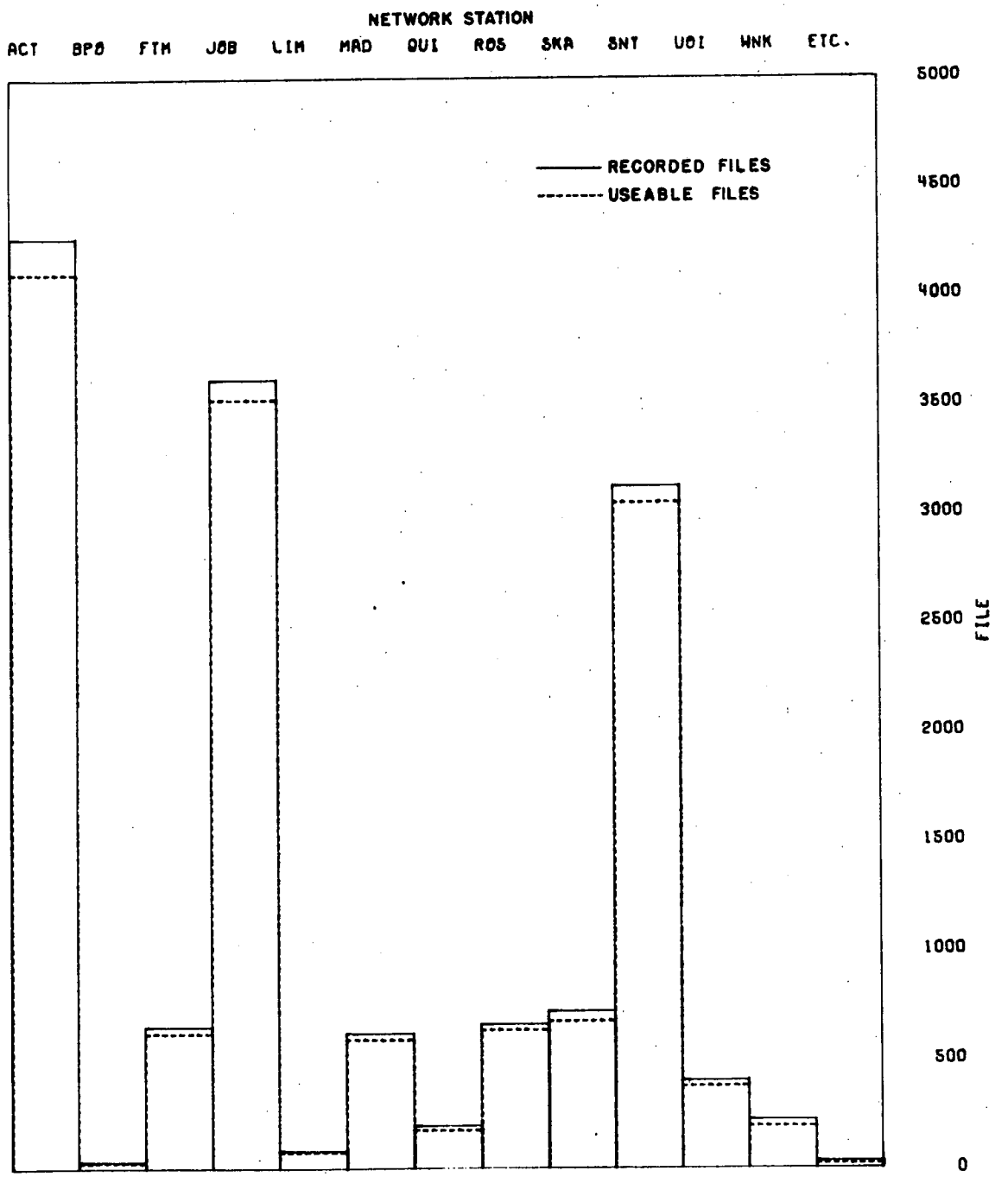


Figure 9. NETWORK Station Recorded and Useable Files for AIMP-D

Table I

Data Processing Efficiency (% Useable Files Recovered)
by NETWORK Station

Station	IPD Input Files	IPD Useable Files	Files Not Useable	% Useable Files
ACT	4,264	4,181	83	98.05
BPO	28	23	5	82.14
FTM	648	628	20	96.91
JOB	3,615	3,564	51	98.58
LIM	79	76	3	96.20
MAD	620	601	19	96.93
QUI	194	179	15	92.26
ROS	661	641	20	96.97
SKA	719	700	19	97.35
SNT	3,126	3,081	45	98.56
UOI	400	376	24	94.00
WNK	218	205	13	94.03
OTHERS	31	18	13	58.06
	14,603	14,273	330	97.74%

III. DATA QUALITY RESULTS

This section describes the data quality results of the useable files sent to the AIMP-D experimenters. Figure 10 contains the time-history data quality results for the AIMP-D Satellite. The quality indicator plotted is the File Quality Index (FQI) and is defined as follows:

$$FQI = \left[1 - \frac{DM}{DP(FN - GT)}\right] \times 100\%$$

where

FN = the number of telemetry sequences recovered

DP = 480 = the number of experimenter data points in a sequence

DM = the number of missing data points contained in sequences which have 23 or fewer missing data points

GT = the number of sequences recovered with more than 23 missing data points

Observe from Figure 10 that a total of 14,200 quality cards "Q" were generated. This number should agree with the useable files (14,273), however, it has been determined that 73 "Q" cards are missing from the data base. It can be seen from the statistics on Figure 10 that the average and standard deviation of the FQI were 99.63% and 0.568% respectively. The x-resolution is 2.744 days, hence the plot shows averages of all files located within an x-resolution cell of 2.744 days. (A vector was drawn from point-to-point.)

Figure 11 plots the cumulative distribution of the FQI values of Figure 10. Observe from the statistics that 50% (probability = 0.5) of the files contained a FQI of 99.50% or better.

Figure 12 depicts the average FQI values by NETWORK station for the AIMP-D data. Table II contains a more detailed breakdown of the data quality statistics by NETWORK station.

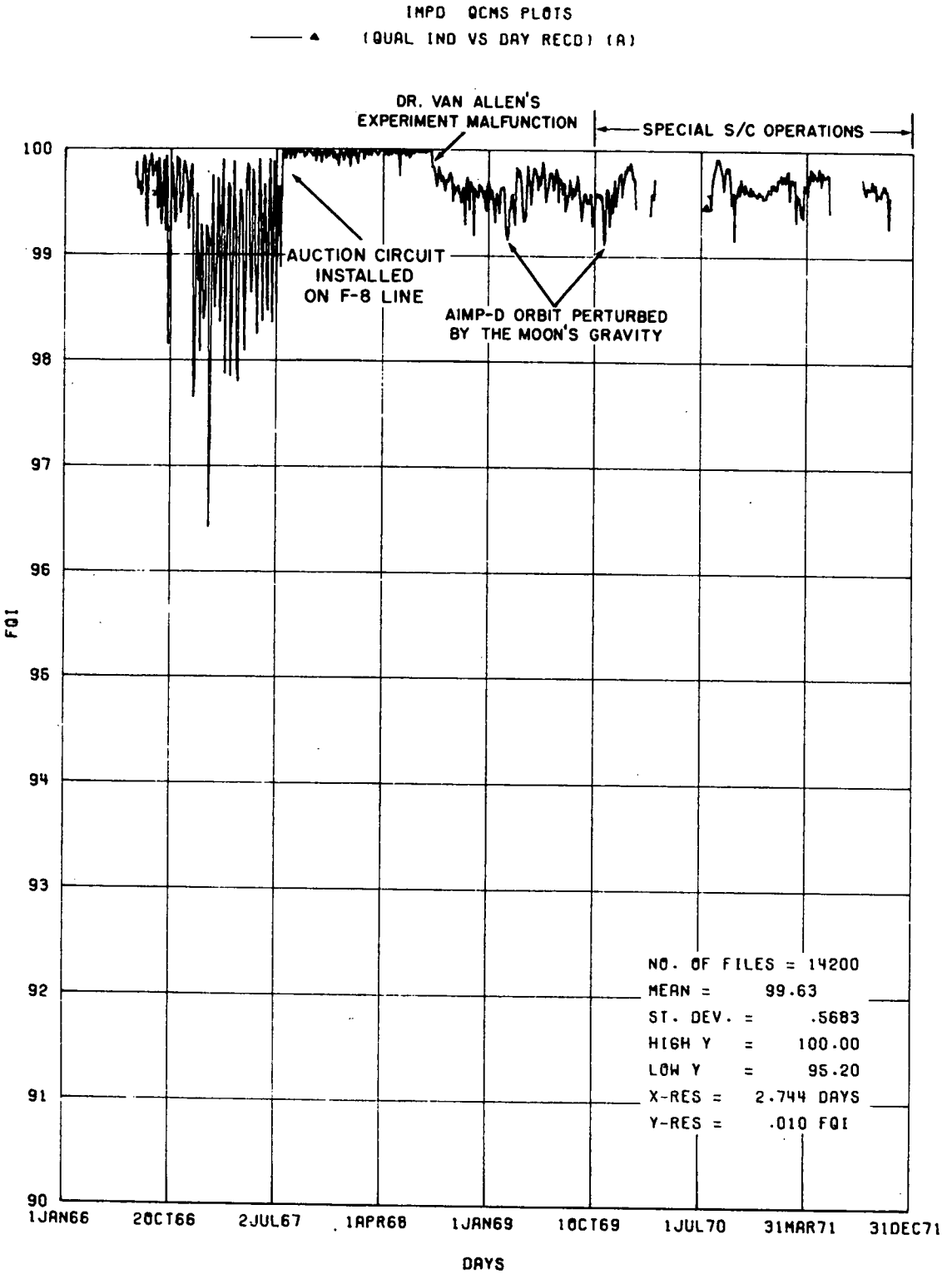


Figure 10. AIMP-D Data Quality History

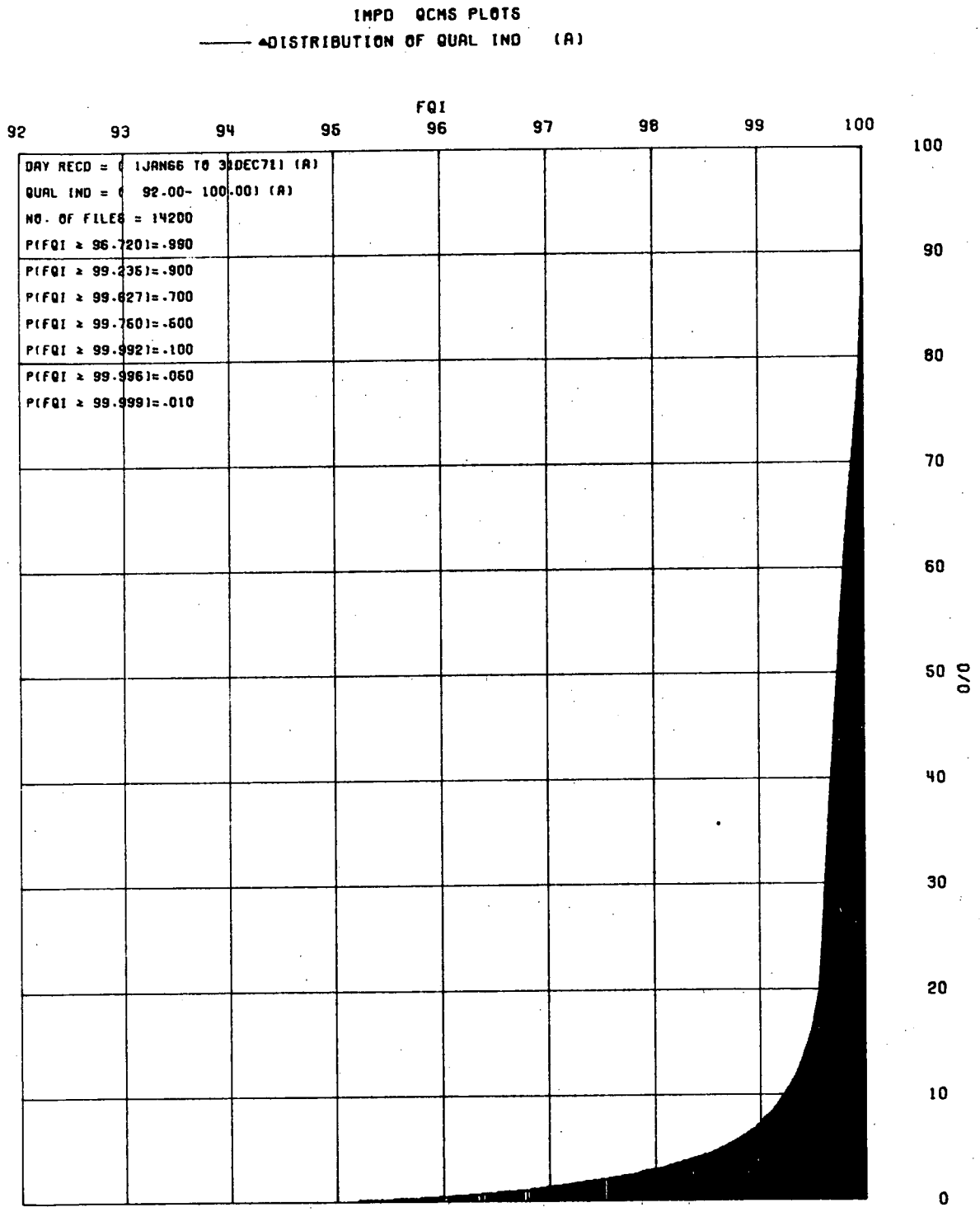


Figure 11. Cumulative Distribution Probabilities of the File Quality Index Values on Figure 10

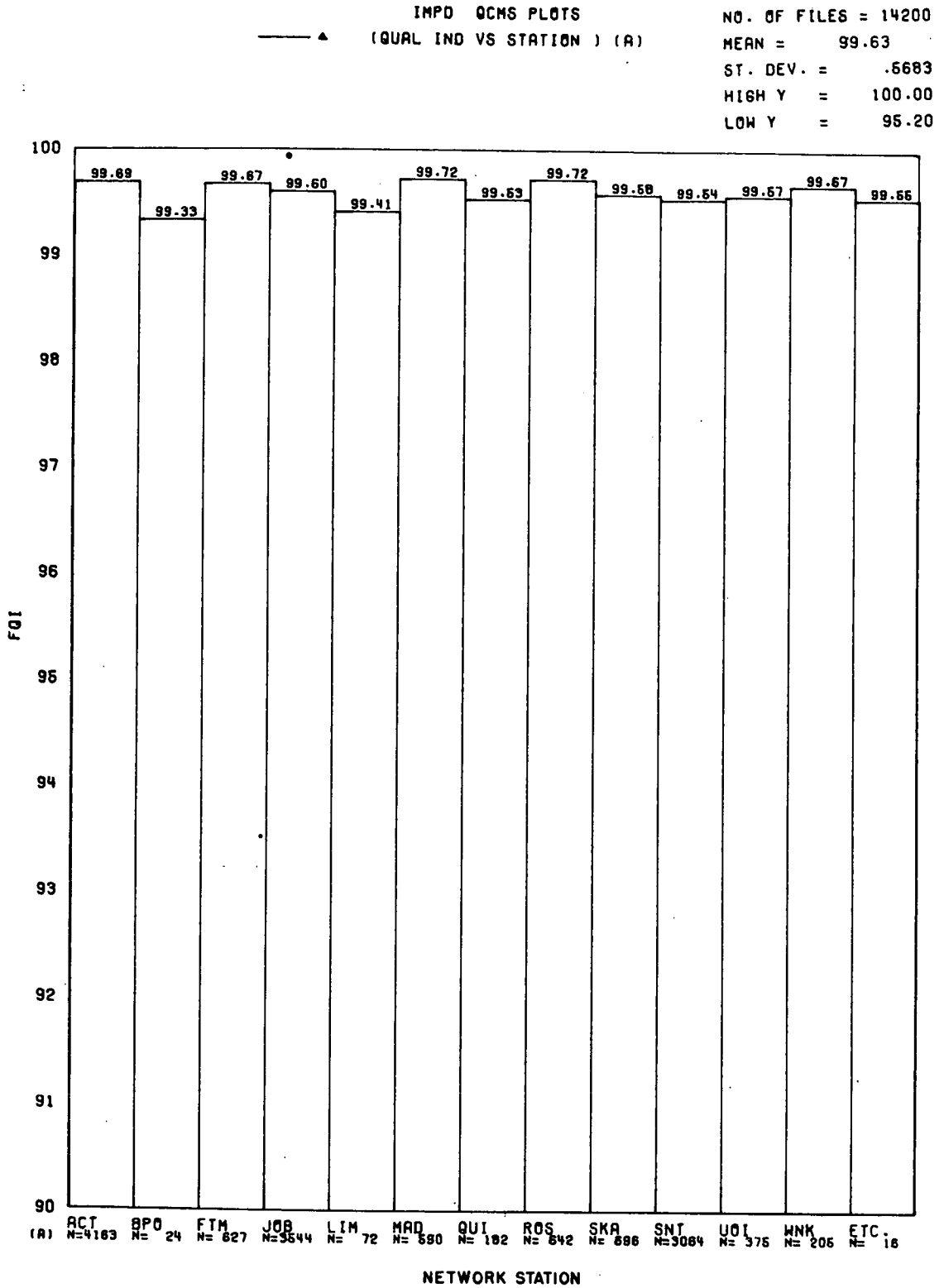


Figure 12. NETWORK Station Average File Quality Index Results for AIMP-D

Table II

NETWORK Station Data Quality Results for the AIMP-D Useable Files

QUALITY CONTROL MONITORING SYSTEM — Y-VARIABLE (QUAL IND) — FILE IMPD — 72/05/12

STATION	NUMBER OF FILES	MEAN	STANDARD DEVIATION	MAXIMUM	MINIMUM	P1 = 99.0	P2 = 90.0	P3 = 70.0	P4 = 50.0	P5 = 10.0	P6 = 5.0	P7 = 1.0
ACT	4163	99.694	.473	100.000	95.210	97.348	99.389	99.650	99.784	99.994	99.997	99.999
BPO	24	99.340	1.271	100.000	96.120	96.116	96.905	99.853	99.925	99.983	99.993	99.999
FTM	627	99.679	.441	100.000	96.050	97.603	99.399	99.686	99.797	99.972	99.991	99.998
JOB	3544	99.607	.628	100.000	95.420	96.691	99.049	99.643	99.775	99.993	99.997	99.999
LIM	72	99.417	.648	99.960	96.950	96.947	98.465	99.495	99.671	99.861	99.878	99.954
MAD	590	99.728	.244	100.000	97.860	98.561	99.558	99.661	99.743	99.988	99.994	99.999
QUI	182	99.539	.543	100.000	96.450	96.498	99.065	99.565	99.681	99.930	99.954	99.995
ROS	642	99.721	.239	100.000	97.620	98.780	99.569	99.640	99.720	99.989	99.994	99.999
SKA	696	99.581	.405	100.000	96.960	97.675	99.123	99.585	99.645	99.982	99.993	99.999
SNT	3064	99.545	.754	100.000	95.200	96.057	98.883	99.620	99.765	99.993	99.997	99.999
UOI	375	99.575	.150	99.850	98.560	98.747	99.449	99.570	99.597	99.689	99.706	99.778
WNK	205	99.672	.257	100.000	97.580	98.963	99.503	99.638	99.690	99.856	99.934	99.996
ETC.	16	99.550	.470	99.960	98.370	98.365	98.745	99.498	99.694	99.934	99.953	99.961
SUMMARY	14200	99.629	.568	100.000	95.200	96.725	99.241	99.634	99.751	99.992	99.996	99.999

* EXAMPLE OF PROBABILITY VALUES: P = 99.0 FOR STATION =ACT ; IMPLIES FOR 99.0% OF THE FILES, QUAL IND= 97.348 OR GREATER.

IV. INFORMATION SYSTEM DELAYS

This section describes the three major Information System delays prevalent in the AIMP-D ground system. The three delays analyzed are: (1) IPD Analog tape receipt minus station record date, (2) IPD digitization date minus station record date, and (3) Experimenter tape shipment date minus station record date. These three delays are labeled on the following graphs as: (1) RDAY - DAYS, (2) DDAY - DAYS, and (3) TDAY - DAYS, respectively.

Figure 13 shows the Digitization and Experimenter Tape shipment delay history. Also shown are three reference lines, i.e., data acquisition (record date) reference (solid diagonal line) and 6-week and 12-week "lag" reference lines (dashed diagonal lines). The x-axis plots the record date. One can observe for data recorded in 1968, practically all data recorded was shipped to the experimenters within 6 weeks. The shaded area represents the delay between the experimenter tape shipment and the digitized date.

Observe the delay resulting from the: (1) "warehouse storage data," and (2) University of Iowa data.

Figures 14 through 19 plot the three major ground system delays. Figures 14, 16, and 18 are the receipt, digitization, and experimenter tape shipment delays respectively, referenced to the data acquisition record date from July 1, 1966 through November 14, 1971.

Figures 15, 17, and 19 are the receipt, digitization, and experimenter tape shipment delays respectively, referenced to the data acquisition record date for all AIMP-D data. There is a slight discrepancy of the file count on Figure 15, 17, and 19 compared to Figure 7; this is primarily due to key-punch error in the accounting system.

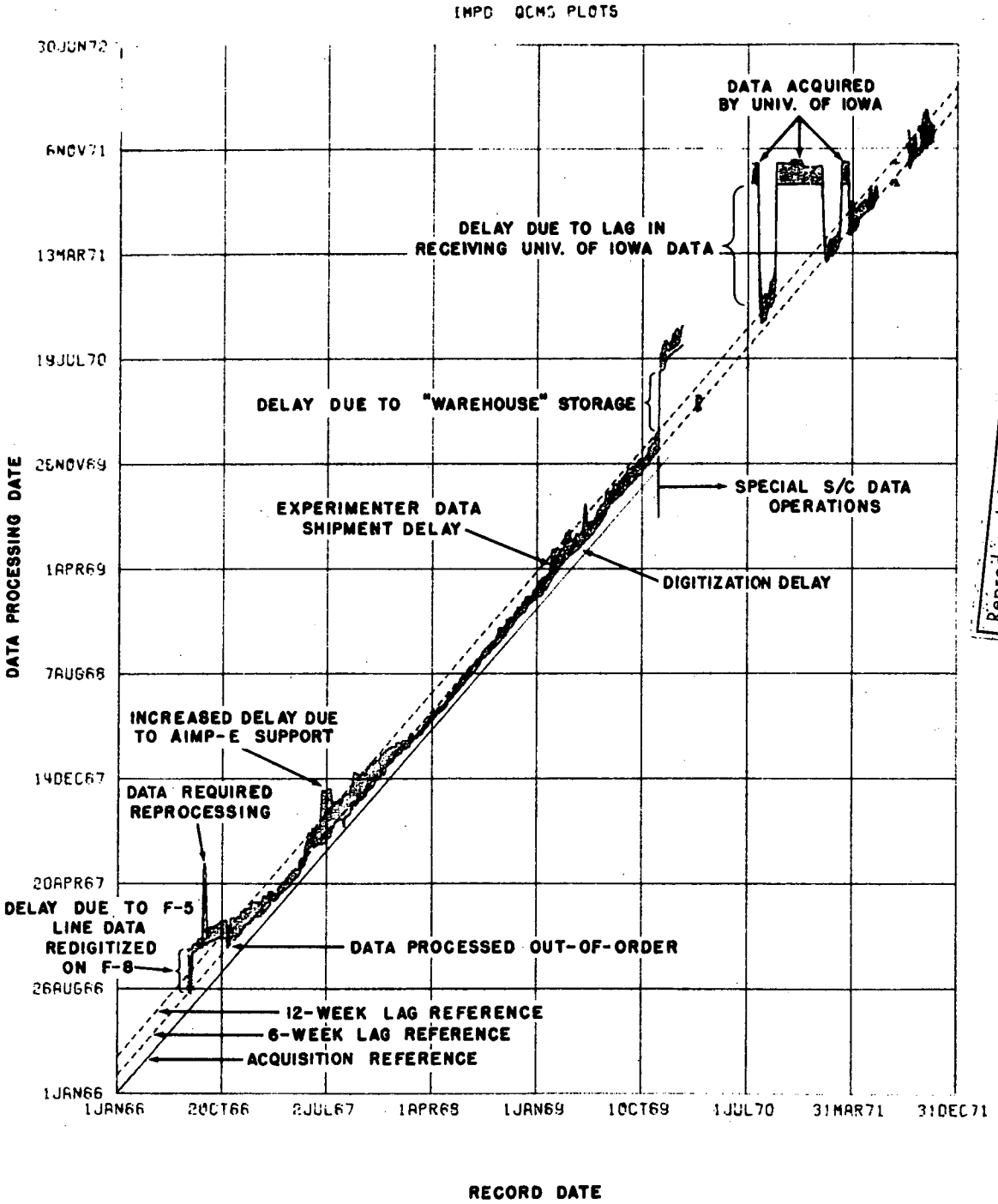


Figure 13. AIMP-D Digitization and Experimenter Tape Shipment Delay History

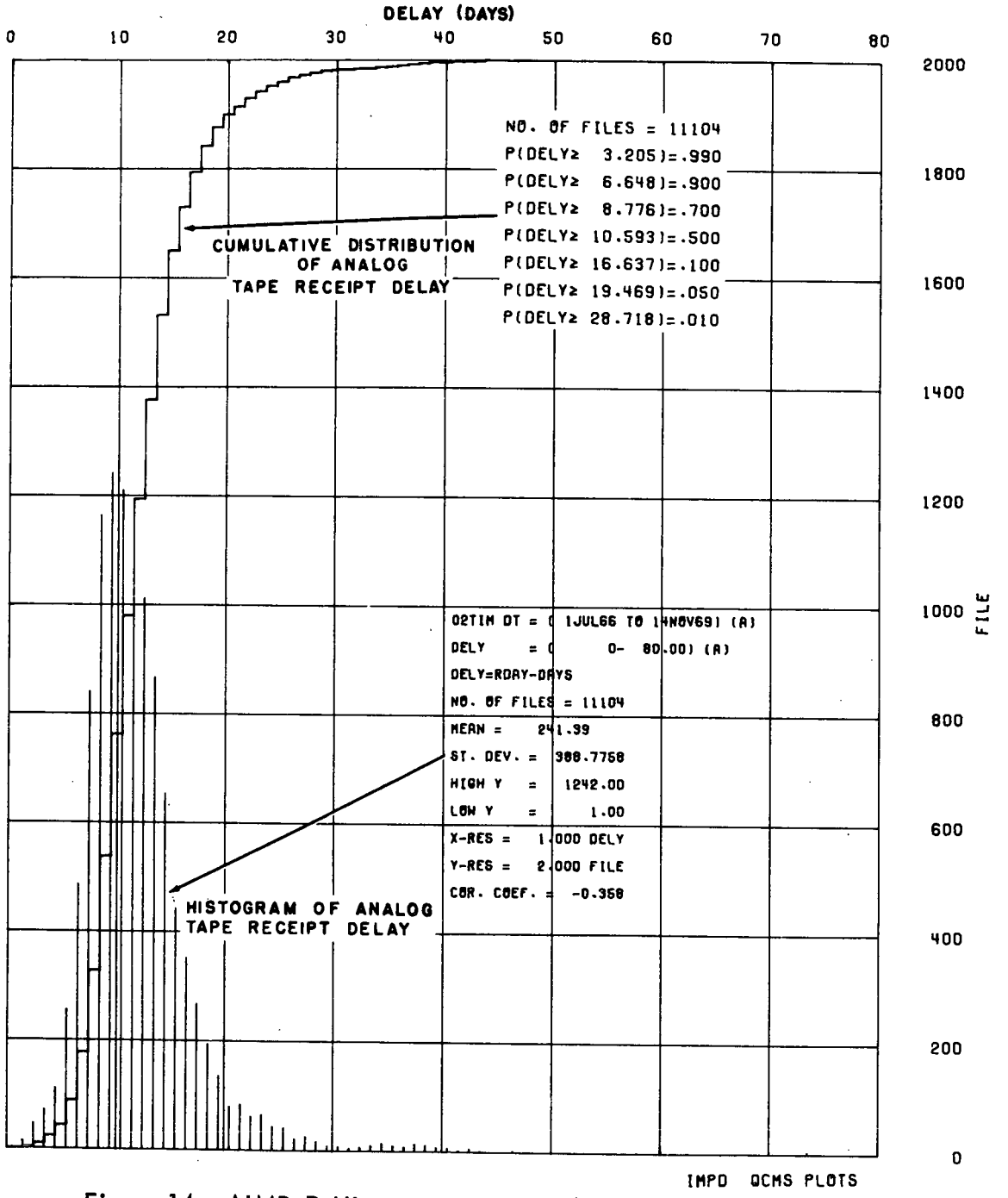


Figure 14. AIMP-D Histogram and Cumulative Distribution of Analog Tape Receipt Date Minus Record Date for Data Recorded July 1, 1966 through November 14, 1969

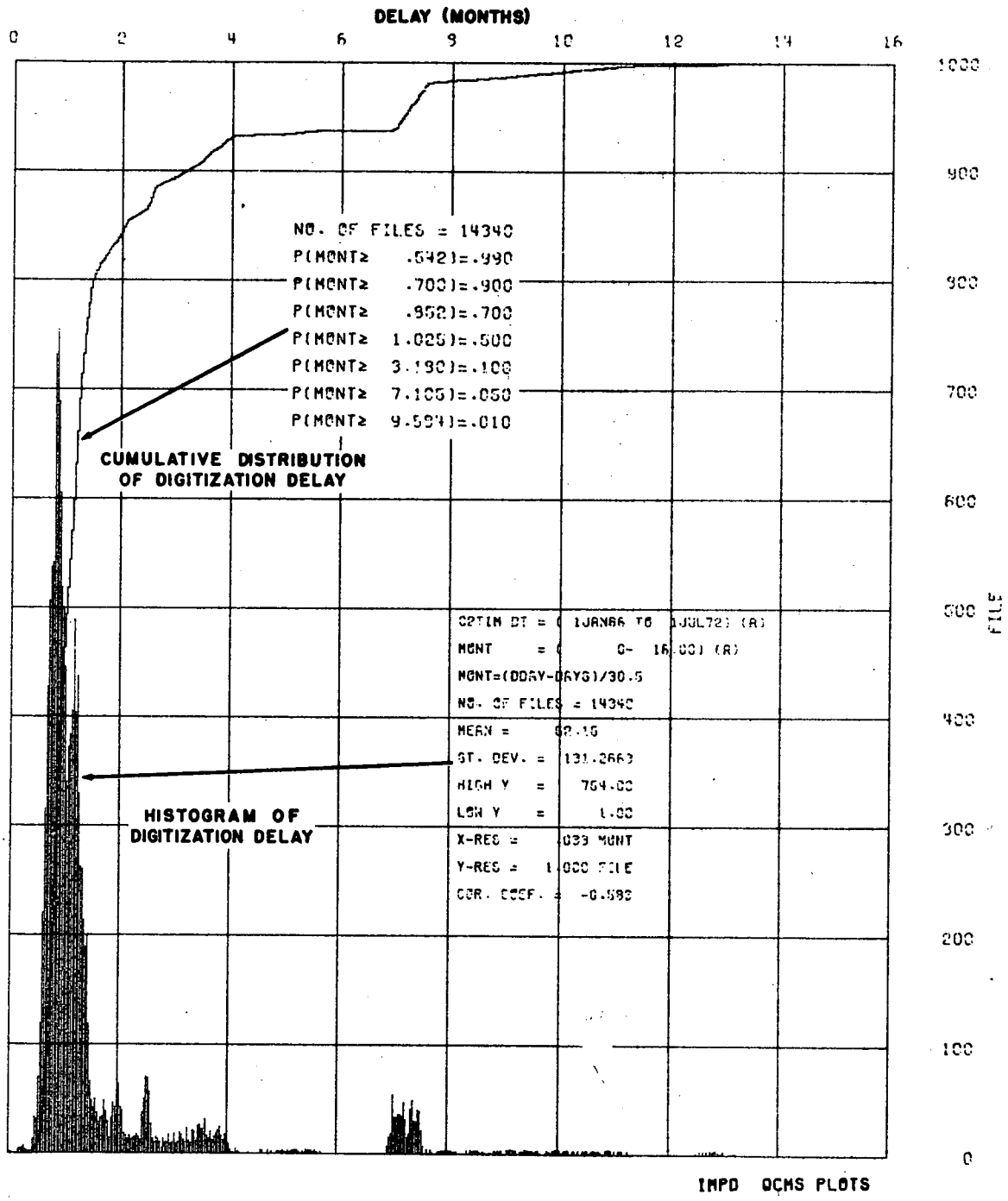


Figure 15. AIMP-D Histogram and Cumulative Distribution of Analog Tape Receipt Date Minus Record Date for all Data

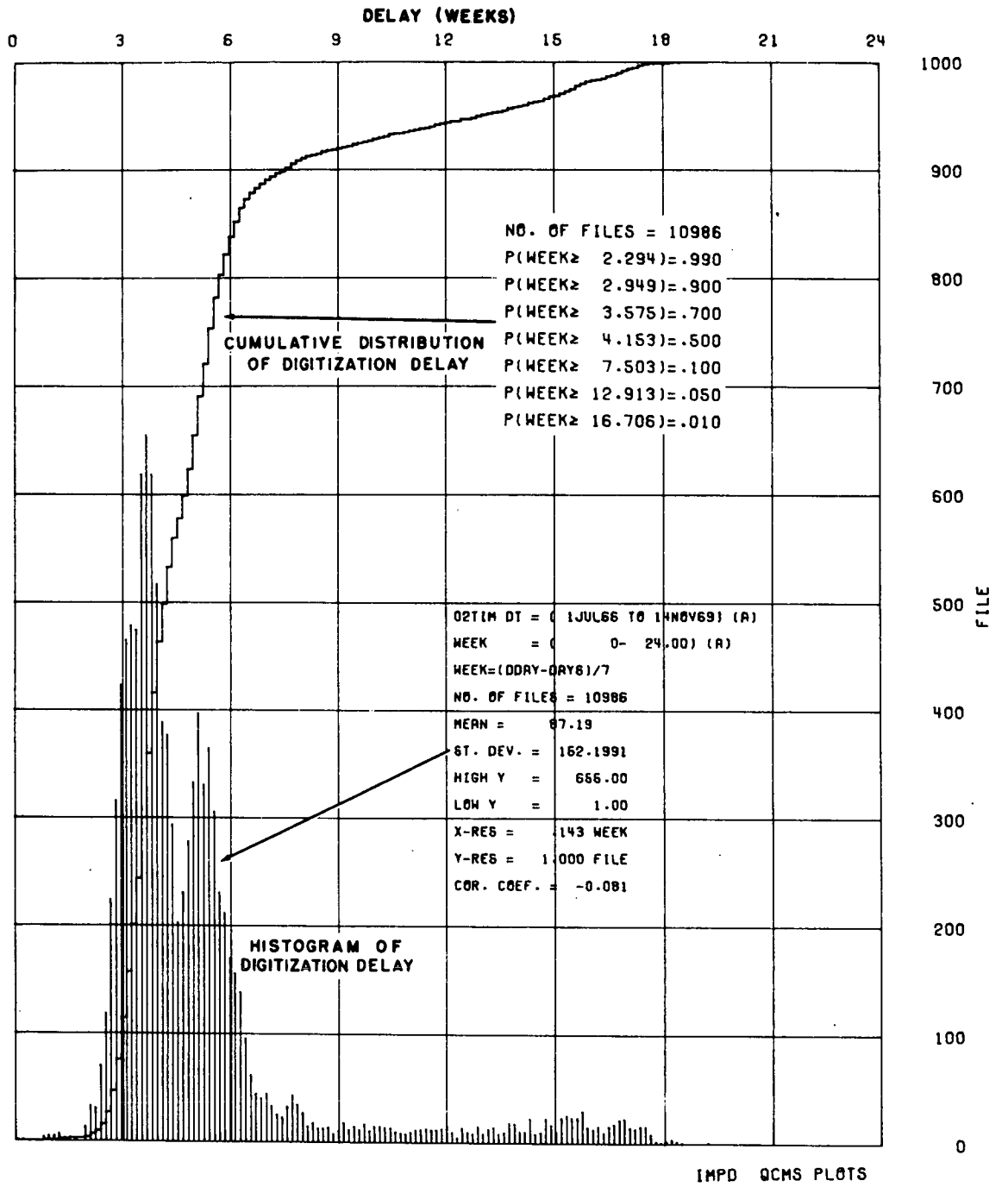


Figure 16. AIMP-D Histogram and Cumulative Distribution of Digitization Date Minus Record Date for Data Recorded July 1, 1966 through November 14, 1969

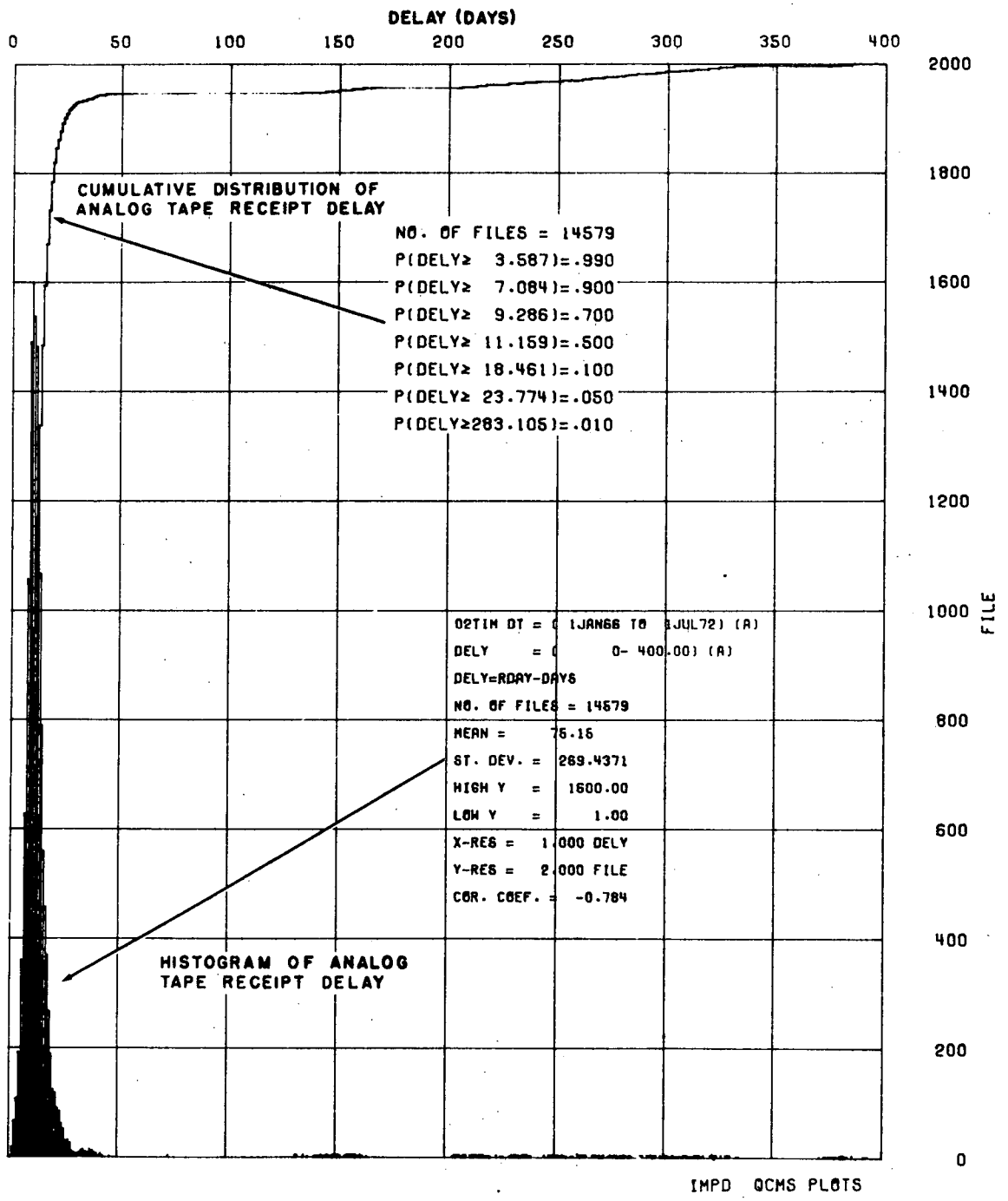


Figure 17. AIMP-D Histogram and Cumulative Distribution of Digitization Date Minus Record Date for all Data

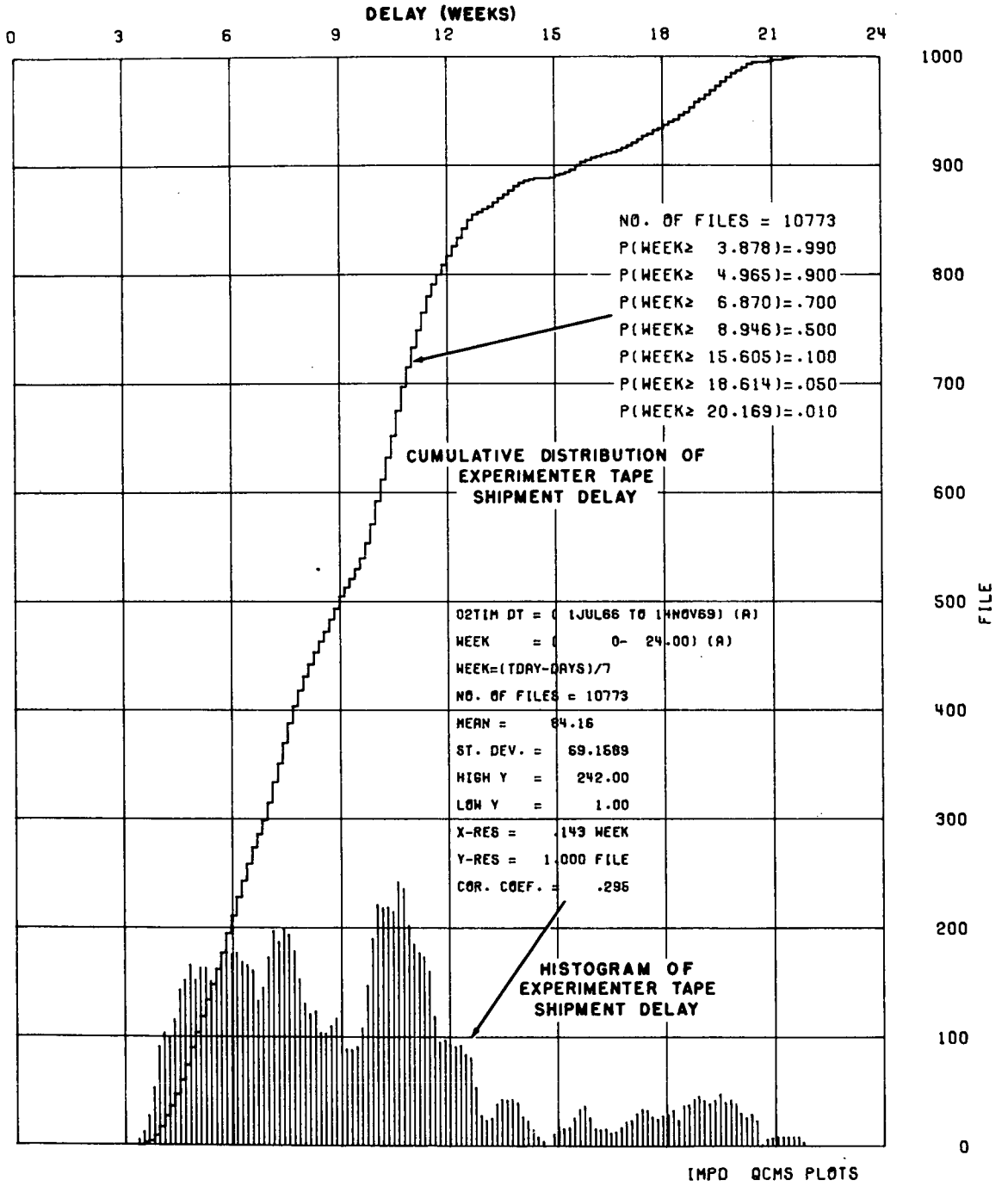


Figure 18. AIMP-D Histogram and Cumulative Distribution of Experimenter Tape Shipment Minus Record Date for Data Recorded July 1, 1966 through November 14, 1969

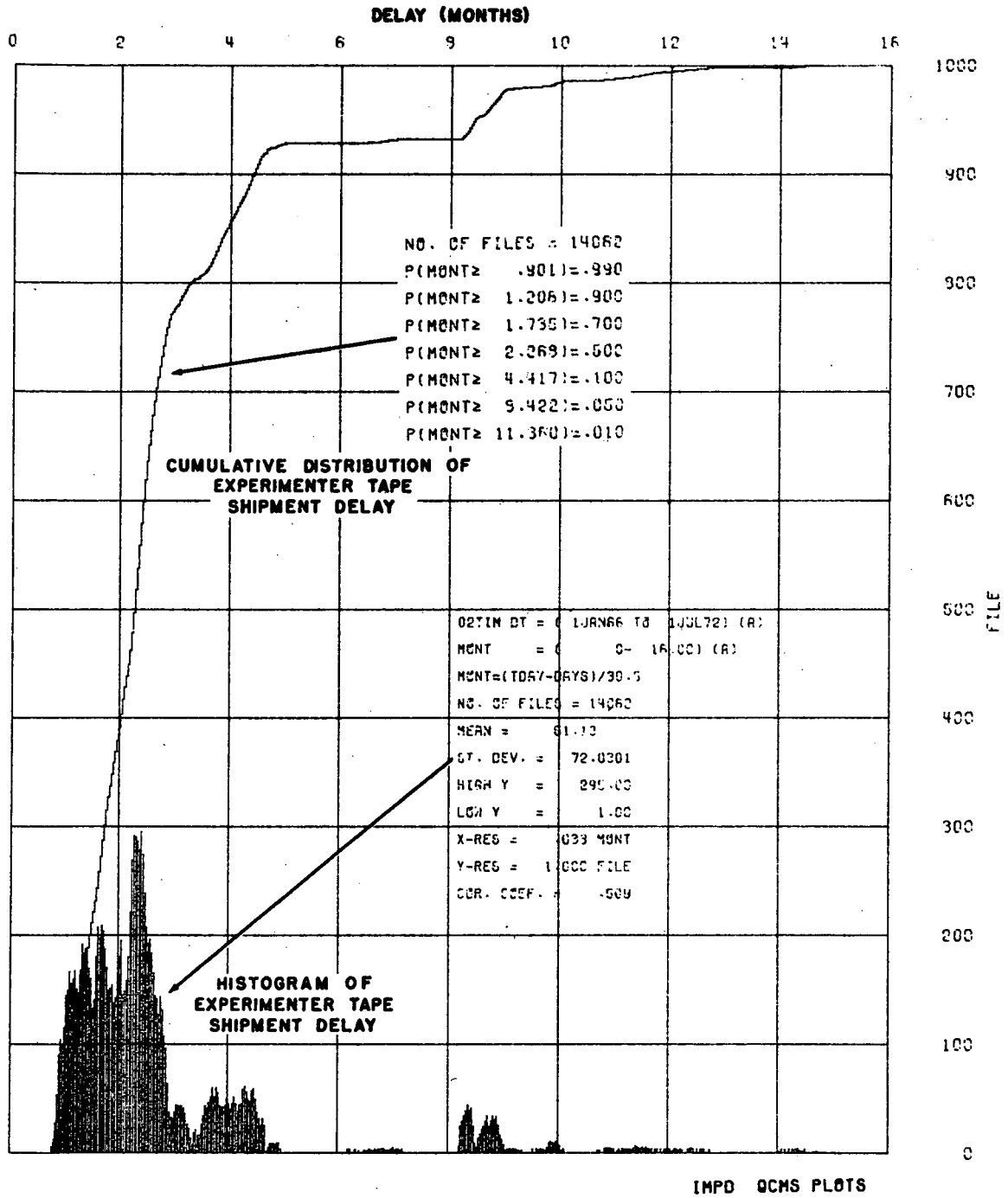


Figure 19. AIMP-D Histogram and Cumulative Distribution of Experimenter Tape Shipment Minus Record Date for all Data

V. SUMMARY

The Data Acquisition, Data Processing History, and various system delays for the Explorer XXXIII (AIMP-D) Satellite have been analyzed using the IPD Accounting system and Quality Control Data bases as inputs to the QCMS. Less than 0.5% keypunch/card errors exist in the data bases.

The time interval analyzed was from July 1, 1966 (Launch) through to the termination date November 1, 1971. Figure 20 summarizes the time-history accumulation of AIMP-D files within the IPD. Results show that 97.7% of the files supplied to the IPD from the NETWORK stations were shipped to the experimenters. From these files, less than 0.4% data was missing within the PFM sequences.

The major system delays were analyzed and the following summarizes the 50 percentile probability delay results during the normal spacecraft operation interval (referenced to record data).

(1) 11 days delay for station tapes to arrive at the IPD

(2) 4.2 weeks delay for analog tapes to be digitized

(3) 8.95 weeks delay for shipment of experimenter data

ACKNOWLEDGEMENT

The author acknowledges contributions made by Tony Maione and John Kern in setting up the data base and operating the QCMS computer system.

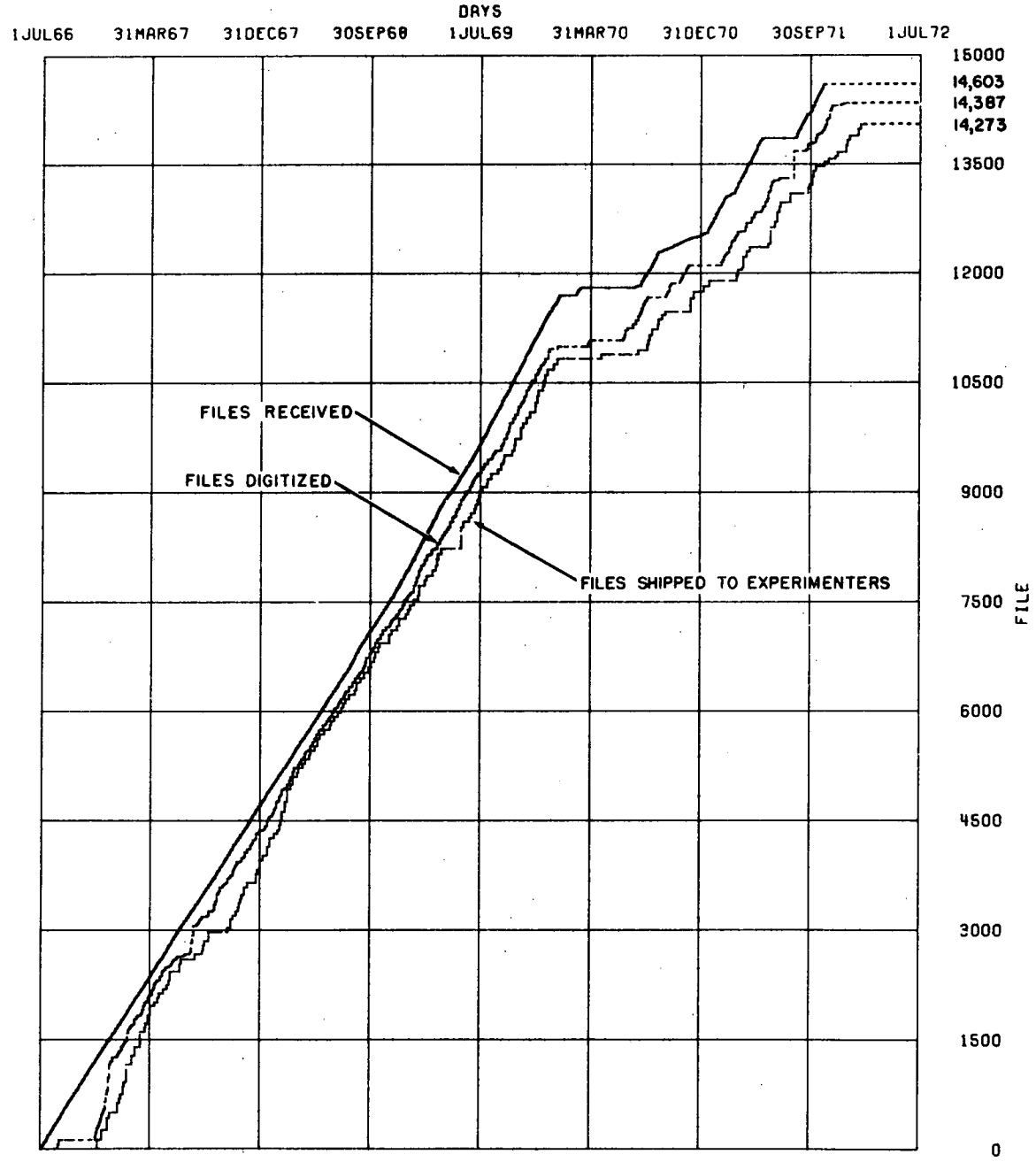


Figure 20. Time-History Accumulation of AIMP-D Files Within the Information Processing Division